VLSI design project, TSEK01

Project description and requirement specification

Version 1.0

Project: Step-up DC-DC converter

Project number: 1

Project Group:

Name	Project members	Telephone	E-mail
	Project leader and designer 1(4)		
	Designer 2(4)		
	Designer 3(4)		
	Designer 4(4)		

Customer and supervisor: Henrik Fredriksson
Office: B-house 3A:509, Phone.: 013-282254, Fax: 013-139282
Email: henfr@isy.liu.se

1 Background

The world of today is virtually covered with sophisticated handheld electronic devices such as mobile phones, PDA:s, portable music devices, GPS-receivers etc. Different parts of these devices require supply voltages which does not match the voltage from the battery and the voltage over an almost discharged battery is substantially different from a fully charged battery. DC-DC converters are often used to solve these issues. The trend to higher and higher level of integration forces these converters into application specific integrated circuits as a part of the mobile system. This document describes the design requirement specification of an integrated step up (boost) converter.

As an example of the capabilities of DC-DC converters, this project will design an integrated circuit capable of fully drive a white light-emitting diode (LED) from a single 1.5 V battery with the use of a minimum number of external passive components. The project will include design of, mainly analog, blocks for example on chip reference, differential amplifiers, oscillator. The project will give knowledge of the problems encountered on chips with multiple power supplies, bootstrapping, regulator feedback issues and circuits for low supply voltage.

1.1 Project goal

The project goal is to design an integrated circuit (IC) in complementary metal-oxide semiconductor (CMOS) technology. Students, participating in this project as project members and project leaders, should learn the different steps of the IC design flow. That includes the given system architecture analysis, simulation, layout implementation and verification. The project students have an optional choice to manufacture the designed IC circuit on a chip. To test the manufactured chips, another course (TSEK10) is available after the project.

1.2 Milestones and deadline

1: Project selection	Week 3
2: Pre-study, project planning, and discussion with supervisor	Week 4
3: High-level modeling design and simulation result (report)	February 11
4: Gate/transistor level design and simulations result (report)	March 7
5: Layout, DRC, parasitic extraction, LVS, post-layout simulations, modification, chip evaluations, and delivery of the completed chip	May 17
6: **DEADLINE**, Final report, and oral presentation	**May 25**

1.3 Parties

The following parties are involved in this project:

1- Customer: Henrik Fredriksson
2- Project supervisor: Henrik Fredriksson

Tasks:

- Formulates the project requirements

- Provides technical support
- Reviews the project documents.

3- Project leader: One of the members in the design team.

Tasks:

- Responsible for organization of the team and the project planning.
- Divides the design and documentation work in an efficient way
- Organizes the team meetings as well as the meetings between the team and supervisor
- Keeps the supervisor informed about the progress of the project (at least one email or meeting per week)

4- Project design members (including the project leader)

- Are equally responsible for project planning and design.
- Participate actively in all the meetings
- Support the team and the project leader
- Keep the team and project leader informed about the progress of their tasks.

2 Project description

A white LED requires a voltage of at least 3 V (3.0 V to 3.8 V) to emit light. The nominal voltage of an alkaline battery cell is 1.5 V (1.2V to 1.6 V). The task is to generate sufficient voltage for the LED from one battery by using a DC-DC converter. There are two major kinds of DC-DC converters. One relying on energy storage in capacitors (charge pumps) and one relying on energy stored in inductors. It's recommended building an inductor based DC-DC converter in this project.

3 Area, performance requirements

The table below summarizes the circuit performance requirements. Each requirement has its number, formulated text, and the given degree of priority. Three degrees of priority are used: high, medium, and low. High is a firm requirement with no possibility of relaxation, while medium requirements can be relaxed somewhat after good motivation.

Requirement	**Requirement text**	**Priority**
1	Supply voltage (battery voltage): 1.2 V to 1.6 V	High
2	LED forward voltage: 3.0 V to 3.8 V	High
3	LED current: > 30 mA	High
4	The system should work with only passive external components	High
5	External components should be 1: as few as possible. 2: as cheep as possible. 3: as small (physically) as possible.	Medium
6	Power efficiency > 70 % (i.e. More then 70 % of the power drawn from the battery should be dissipated in the LED)	High
7	Stability: > 65 degree phase margin in the control loop	Medium
8	Less then 5 % current ripple through the LED	Medium

9	Schematic and layout must be verified by simulation	High
10	Chip design area ~ 1.2 mm^2 (see Figure)	Medium
11	Chip core area < 700µm x 800µm = 0.56mm^2 (see Figure)	High
12	Total project pin count < 17 (max 15 active + 2 power supply)	High
13	Design technology is AMS 4-Metal 0.35 µm CMOS	High
14	The most important system nodes should have off-chip access pins	Medium
15	On-chip metal wire current densities < 1 mA/µm	High

- All requirements in the table should be fulfilled in "typical", "slow", and "fast" process corners and temperature between 25 and 110 ^oC

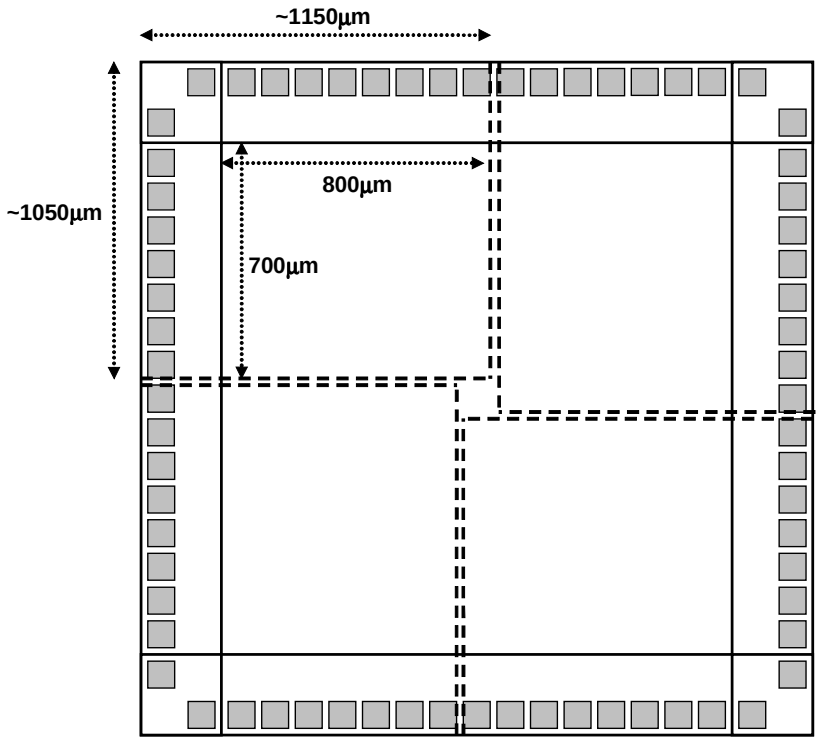

Figure 1: A 5mm^2 chip will be shared by 4 independent projects (4 teams). Each project will utilize a 700x800µm^2 area for core layout and 17 pads.

4 Suggested implementation structure

The project group is free to choose which structure to implement as long as it fulfills the requirements in section 3. As a suggestion the supervisor recommends a PWM clocked step-up converter as shown in figure 2. This suggestion comprises on chip oscillator, reference generator, error amplifier, PWM regulator and switch transistor. Off chip inductor, schottky diode, decoupling capacitor and LED.

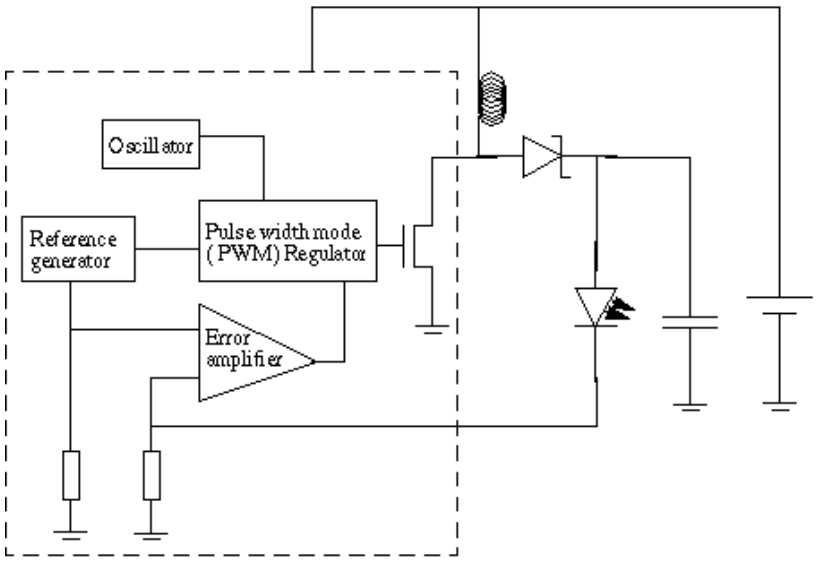

Figure 2: Block-diagram of suggested implementation structure.

5 Available resources

- Scientific publication database (available from LiU):

♦ IEL – IEEE/IEE Electronic Library, http://www.bibl.liu.se/english/databas/

5.1 Tools

♦ Circuit simulation and layout tools from Cadence , http://www.cadence.com/

6 References

DC-DC Converter Tutorial http://www.maxim-ic.com/appnotes.cfm/appnote_number/710

External components http://www.elfa.se

J.M. Rabaey, A. Chandrakasan, and B. Nikolic., “Digital Integrated Circuits”, 2nd ed., Prentice Hall, 2003, ISBN 0-13-120764-4.

N. Waste and K. Eshraghian, “Principles of CMOS VLSI Design”, Addison-Wesley, 1993.

D.A. Johns and K. Martin, “Analog Integrated Circuit Design”, John Wiley & Sons, 1997.

R.J. Baker, H.W. Li and D.E. Boyce, ”CMOS Circuit Design, Layout, and Simulation”, IEEE Press, 1998.

S.-M. Kang and Y. Leblebici, “CMOS Digital Integrated Circuits: Analysis and Design”, McGraw-Hill, 1999

For more literature references consult with your supervisor.